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ON ROD AND CONE VISUAL ACUITY

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16. Abstract

Dark and light visual acuity of various parts of the eye were determined and results were compared with the theory.

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Max Schultze, on the basis of comparative anatomy, and J. v. Kries, on the basis of physiological observations, have concluded that we have a bright and a dark apparatus in our retina. The cones are in the bright apparatus, which has indifferent light sensitivity, good visual acuity and good color sense. The rods are part of the dark apparatus and are sensitive to light, with low visual acuity and no color sense at all. /433*

If this theory is correct, there must be a rod visual acuity and a cone visual acuity, and it must be quite easy to measure them separately. First, one studies a dark-adapted eye with weakly lighted objects in a dark room. Then one studies light objects in the daylight.

There is already a report from J. v. Kries (Centralblatt VIII, p. 695) on this. He and his student, Buttmann, found that the dark visual acuity between the center of the retina and the blind spot remains the same between 4° and 12°, that it decreases in a certain sense to zero at the center of the retina, and that the dark visual acuity and bright visual acuity remain the same from the blind spot to the edge of the retina.

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* Numbers in the margin indicate pagination in the original foreign text.

During the past summer semester, I studied this problem, under the direction of Docent Dr. A. E. Fick (Zurich), and found the following:

The bright, or cone, visual acuity (see the dotted curve in Figure 1) is greatest in the center of the retina. Then it falls off uncommonly rapidly toward 5° in the horizontal meridian; decreases less steeply from 5° to 30°; and curves with a quite easy slope to the edge. This agrees with what we would expect from the Schultze - v. Kries theory, because the cones are densest in the fovea, because they are more slender here than in the other parts of the region containing only cones. At the edge of the yellow spot, the / 434

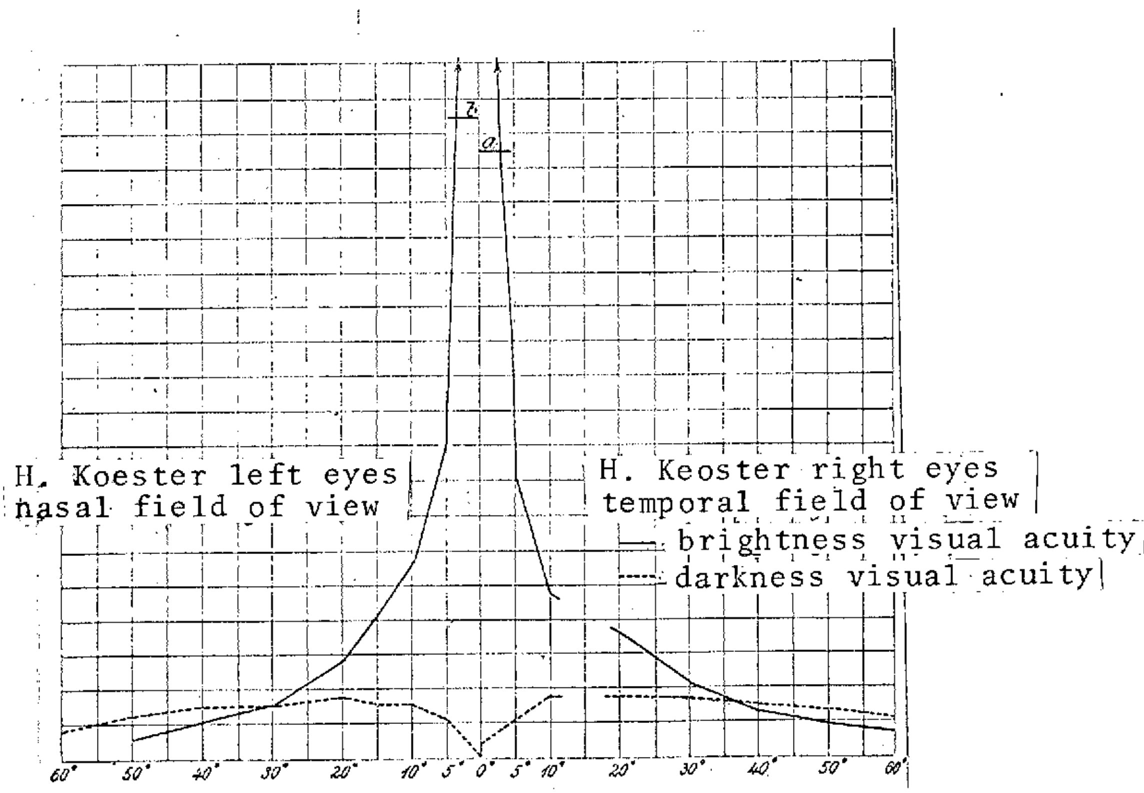

Figure 1

number of cones per unit area decreases, because the rods begin to be interspersed among the cones here. Not far from the yellow spot out to the edge of the retina, the number of cones per unit area remains constant. The fact that there is still some, although slight, decrease in visual acuity is easily explainable by the assumption that it is not only the amount of visual cells per unit surface which determines the degree of visual acuity.

We found the dark, or rod, visual acuity equal to zero in the center of the retina, Small objects were invisible here at the light intensity selected for the experimental series. Large objects were detected, to be sure, but not with the fovea, because the retinal images of these larger objects extended well beyond the fovea. From 5° to 10° in the major horizontal arc, the dark visual acuity increased rapidly. Then it remained nearly the same out to the edge of the region studied. This agrees with the fact that the amount of rods per unit area is nearly the same, even relatively near the yellow spot, as it is in all the remaining periphery of the retina. / 435

Thus, we found the dark visual acuity to be just what we could expect from the Schultze-v. Kries theory.

The fact that the curves of cone acuity and rod acuity intersect at 30° to 40° — that is, that our lateral detection of dimly lighted objects by the dark-adapted eye is better than that for equally large bright objects in daylight — does not by any means contradict the theory. On the contrary, it very distinctly shows that the two curves are independent of each other.

To be sure, one phenomenon did appear that could present a certain difficulty for the demonstration presented by v. Kries. This is the fact that even 5° laterally from the center of the retina, no rod vision, but outstanding cone vision could be seen. I shall call vision with a retinal site containing mostly rods rod vision, such as a site 30° lateral at the side of the center of the retina. I shall call vision with the center of the retina itself, which certainly contains only cone-containing retinal sites, cone vision. Now rod vision and cone vision differ as follows:

If I observed a dimly lighted object with a retinal site 30° lateral, it appeared white and gleaming. If its form could not be detected, this was not because of insufficient brightness, but because of inadequate size. Accordingly, increasing the brightness by no means made the object more distinct. On the contrary, if we increased the light source, the same object did not appear more distinct, and we did not get an improvement even with quite intensive illumination, but a quite unpleasant feel of glare.

The situation was quite different if I fixed on a dimly lighted object, i. e., looked at it with the center of the retina, which contains only cones. Now the dimly lighted object did not appear white, but gray, as a diffusely bounded gray spot. The detection failed due to insufficient brightness. In this case, with stronger illumination, the fixated object became more and more distinctly bounded as the brightness increased, retaining its contours even with the brightest illumination which we could produce with our apparatus. In this experiment, too, I had absolutely no feeling of glare.

Now, if I observed with a retinal site which was 5° laterally from the center of the retina, the phenomena which appeared were entirely the same as with fixation, i. e., in observation with the center of the retina, which certainly contains only cones. It appears, therefore, that in my eyes a segment of the retina 10° in diameter is free of rods, or at least has so few rods that only the cones operate, even under the conditions most favorable for the rods.

I can present only a brief preliminary report here. The detailed treatment will appear as a dissertation in the winter semester.

For explanation of the figure, it should be noted that the solid curve, i. e., that for the bright acuity, is truncated, so that we can consider the right branch to intersect the ordinate twice as high as point a, and the left branch to intersect twice as high as point b.